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(58) Field of Search
UK CL (Edition O) B1C CPJA
INT CL[6] B01F 5/00 5/04 5/06

(54) Material treatment

(57) A device (10) for inducing swirling in fluid comprising a conduit (12) through which fluid is passable, and motion inducing means (14) operable to create swirling motion. in fluid passing through the device (10), the device (10) being arranged to define a single passageway (16) therethrough which enables generally unobstructed movement of fluid, and solid or semi-solid material in the fluid generally along the axis of the passageway (16). The motion inducing means (14) is shaped to blend into the internal surface (15) of the device (10) to present no projections or recesses that could obstruct flow of fluid and solid/semi-solid material in the fluid.

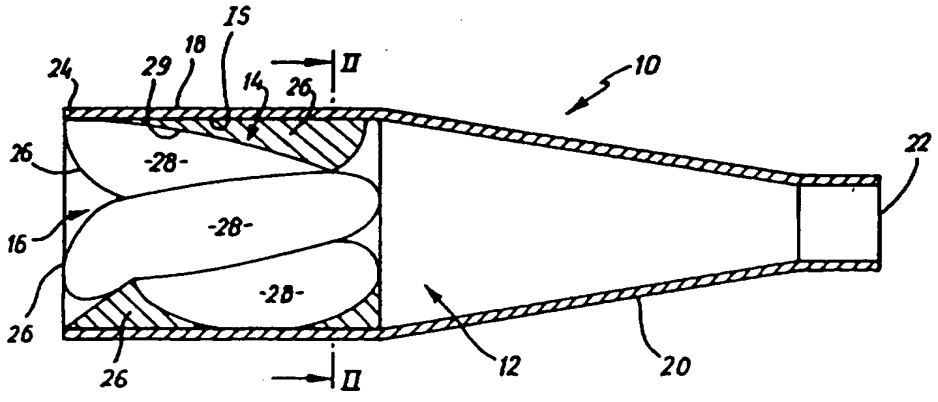

FIG.1

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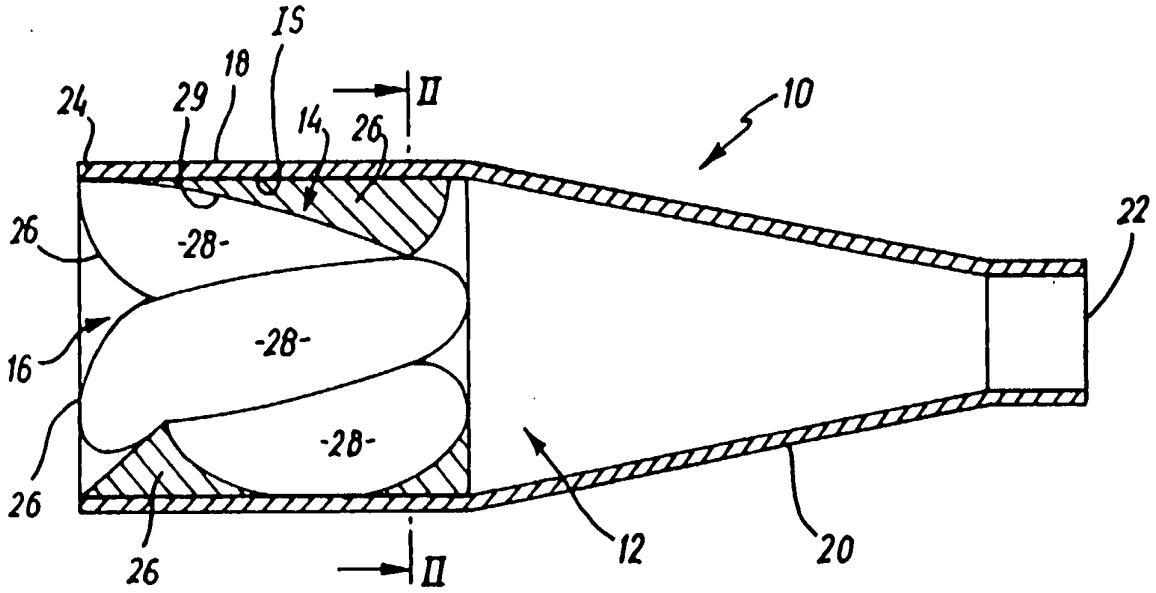
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.



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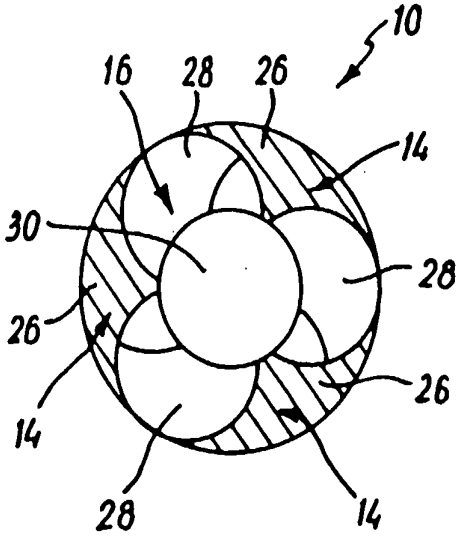

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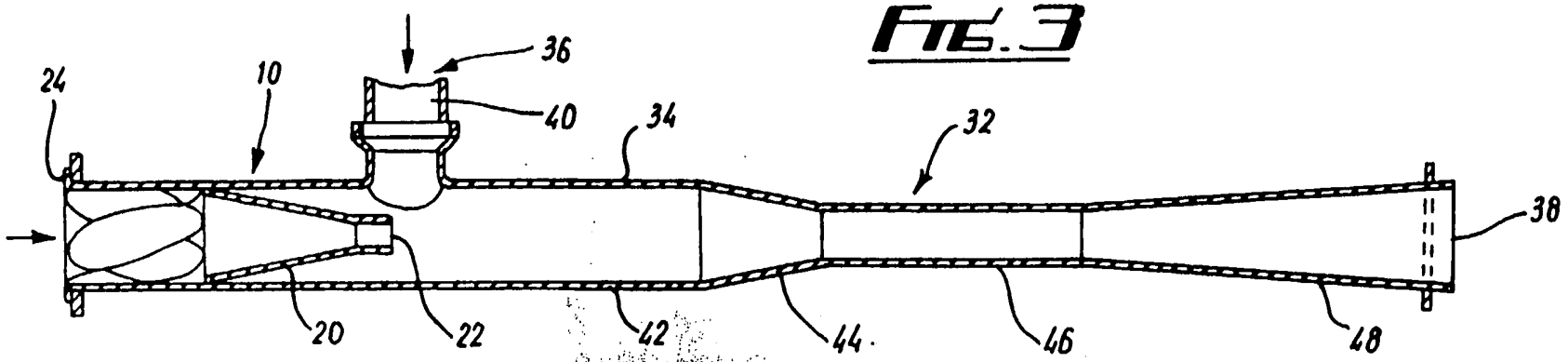

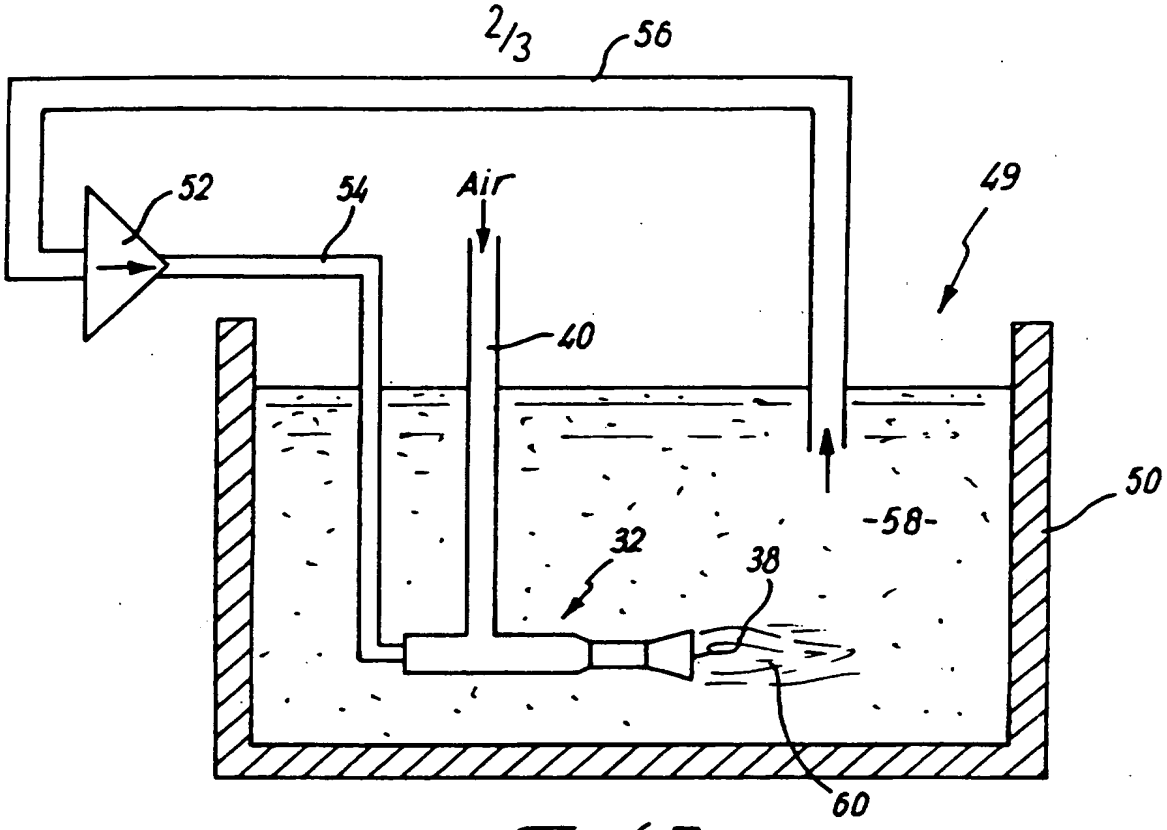

FIG. 4

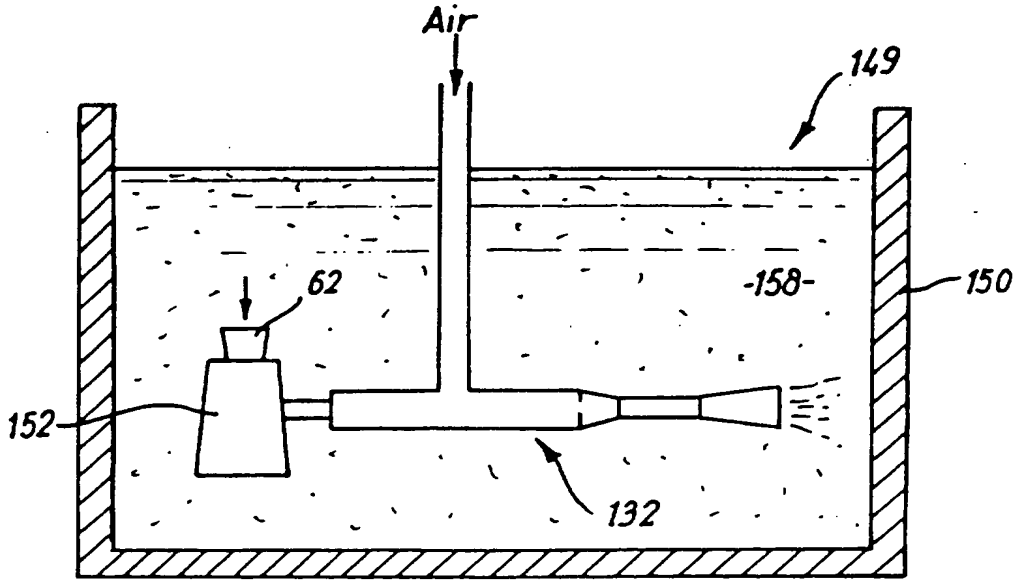

FIG. 5

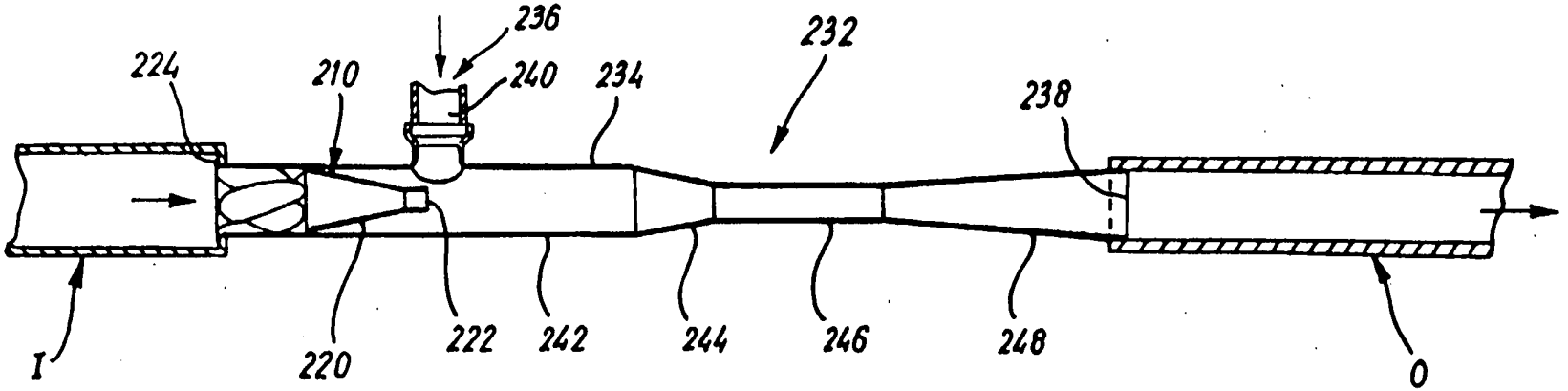

FIG. 6

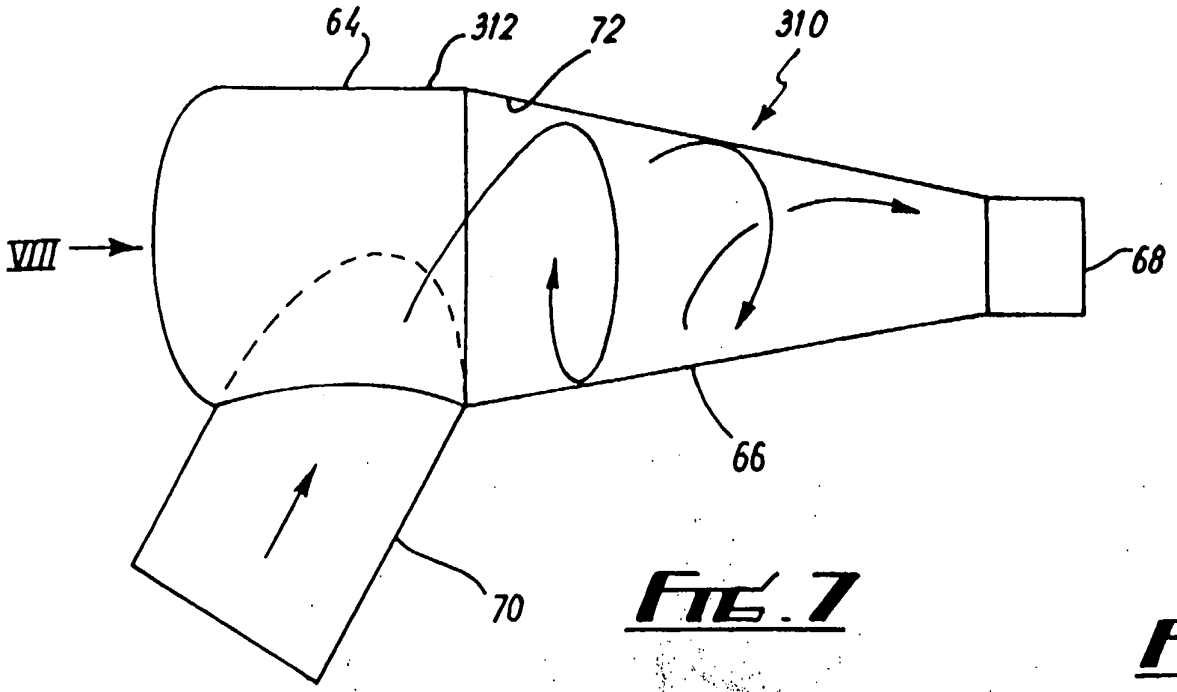

FIG. 7

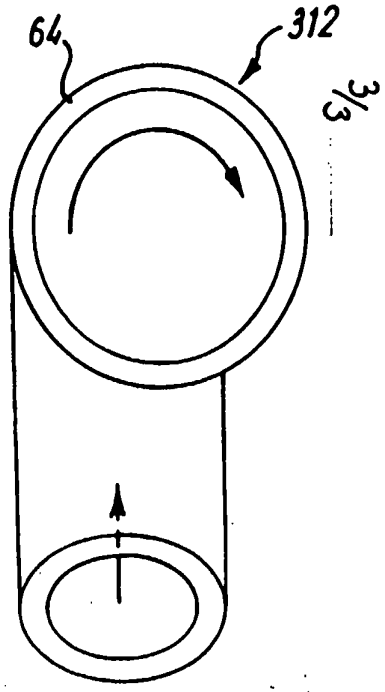

FIG. 8

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Material Treatment

The present invention relates to material treatment and apparatus usable therein, and particularly but not exclusively to effluent treatment.

Conventional apparatus for treating effluent, and in particular sewage, often comprises means operable to mix and aerate the effluent to enhance decomposition of the waste material by bacteria. Such means often comprises injectors which have been found to provide inefficient aeration and mixing and moreover often require pumps to assist in the provision of air to aerate the effluent.

It is an object of the present invention to obviate or mitigate one or more of the above or other disadvantages of the prior art.

According to the present invention there is provided a device for inducing swirling in fluid, the device comprising a conduit through which fluid is passable, and motion inducing means operable to create swirling motion in fluid passing through the device, the device being arranged such that a passageway is provided therethrough which enables generally unobstructed movement of fluid and solid or semi-solid material in the fluid generally along the axis of the pathway.

Preferably the motion inducing means is so arranged to induce a swirling motion in fluid pumped into the device, preferably in a direction towards an outlet of the device.

Preferably the motion inducing means defines, at least in part, a channel twisting along the perimeter of the passageway, along which some of the fluid is moved and thereby caused to swirl.

Preferably a plurality of channels is provided in the passageway, and preferably three channels are provided giving the passageway a generally Y shaped cross-section.

Preferably the motion inducing means comprises formations extending from the inside surface(s) of the conduit to define said channel(s) and desirably a central portion of the passageway generally along the axis of the conduit.

Preferably each formation comprises a rib which follows a twisting, and preferably a generally spiral path along the passageway. Preferably the formations are shaped to present minimal obstruction to the movement thereover of fluid and any solid and/or semi-solid matter therein and to facilitate entry of

fluid into the passageway. The formations may taper towards and preferably blend into the inside of the device at or near an inlet end of the device generally in the direction of the longitudinal axis of the passageway. The formations are preferably configured to present no recesses or projections capable of obstructing or holding matter in fluid moving through the passageway. Preferably the sides of the formations blend into the internal surface(s) defining the passageway.

Preferably the conduit comprises a first part of uniform cross-section and a second part of tapering cross-section, preferably reducing in cross-section toward the outlet, thereby providing acceleration of fluid along the second part, towards the outlet. The degree of tapering may be varied to increase and/or decrease the pressure of fluid in and leaving the second part, as desired. The motion inducing means is preferably provided in the first part, but may extend into the second part.

Alternatively or additionally, the motion inducing means may comprise a second conduit connected to communicate with the said conduit and inclined relative thereto, and preferably located downstream of the said conduit, such that fluid passing through the said conduit to the second conduit impacts the inside of the

second conduit, the impact causing the fluid to swirl, and then preferably to move towards an outlet in the second conduit.

Preferably the second conduit tapers in cross-section, reducing in cross-section from the direction of the conduit to the outlet, thereby providing for acceleration of the swirling fluid toward the outlet.

Preferably the said conduit communicates with the second conduit in non-central alignment, such that fluid passing from the said conduit to the second conduit is caused to adopt a combined rotational and longitudinal motion along the second conduit, and hence adopt a swirling motion.

Further according to the present invention there is provided a fluid mixing arrangment comprising a device according to any of the preceding ten paragraphs and a mixing chamber in communication with an outlet of the device and also comprising a supply conduit in communication with the chamber and connectable to a second fluid supply, and a discharge opening, the outlet of the device being located to send swirling fluid therefrom into the chamber to cause fluid to be drawn from the second fluid supply and mix with the swirling

fluid from the device and preferably to move towards the discharge opening.

Preferably the outlet is located adjacent the connection of the supply conduit to the chamber. Preferably the motion created by the device in fluid exiting therefrom is sufficient to reduce the pressure in the chamber at least at or near said connection to cause fluid to be drawn from the second supply which may be at or above atmospheric pressure. Movement of fluid from the second supply may be assisted by pumping and/or blowing means.

Preferably the fluid from the second supply is gaseous and the arrangement provides aeration of a liquid with the gas from the second supply to produce an aerated mixture of liquid to be discharged through the opening.

The chamber may comprise a portion that reduces in cross-section in the direction towards the discharge opening, to provide further acceleration of fluid outputted from the device, toward the discharge opening. The reduction in cross-section may be variable to provide the desired pressure of fluid moving therealong.

The chamber may comprise a portion, preferably

between the said portion and the discharge opening, the discharge portion increasing in cross-section in the direction towards the opening, to cause the fluid to be discharged from the arrangement in generally a plume.

Preferably the arrangement comprises a part of a fluid treatment conduit system in which the arrangement treats fluid by mixing as aforesaid and discharges the fluid into a further conduit to carry the fluid therefrom away from the opening.

According to a further aspect of the present invention there is provided fluid material treatment apparatus comprising a fluid mixing arrangement according to any of the preceding sixteen paragraphs and a reservoir for material, the discharge opening of the arrangment being in communication with the reservoir such that fluid mixture produced by the arrangement is discharged into the material in the reservoir.

Preferably means for recycling material being treated is provided, and may comprise a conduit system to link the reservoir to the device such that material is recycled from the reservoir, pumped through the device, mixed in the arrangement with fluid from the second supply and discharged back into the reservoir. The fluid from the second supply is preferably gas, and desirably air, such that the arrangement also provides

aeration of the pumped fluid.

The apparatus preferably comprises effluent treatment apparatus and desirably sewage treatment apparatus, operable to pump effluent/sewage through the device to cause the effluent/sewage to swirl and be aerated as described above, and to discharge aerated effluent/sewage into the reservoir, to facilitate degradation of the effluent/sewage, for example, by bacteria.

According to a still further aspect of the present invention there is provided effluent treatment apparatus comprising a device for inducing swirling motion in effluent passing therethrough.

Preferably the device is according to any of the preceding paragraphs.

The present invention also provides a method of mixing fluid using a device, and/or apparatus according to the preceding paragraphs.

The invention also provides for a method of treating effluent using a device, arrangement and/or apparatus according to any preceding paragraph.

Preferred embodiments of the present invention will now be described by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1 is a cross-sectional view of a device according to the present invention;

Fig. 2 is a cross-sectional view along the line II-II of the device shown in Fig. 1;

Fig. 3 is a cross-sectional view of a mixing arrangement according to the present invention;

Fig. 4 is a diagramatic representation of treatment apparatus according to a first embodiment of the present invention;

Fig. 5 is a diagramatic representation of treatment apparatus according to a second embodiment of the present invention;

Fig. 6 is a diagrammatic representation of treatment apparatus according to a third embodiment of the present invention;

Fig. 7 is a diagrammatic side view of a device according to a second aspect of the present invention;

and

Fig. 8 is a view of the device in Fig. 7 in the direction VIII.

Refering to the drawings, there is provided a device for inducing swirling in fluid, the device 10 comprising a conduit 12 through which fluid is passable, and motion inducing means 14 operable to create swirling motion in fluid passing through the device 10, the device 10 being arranged to define a passageway 16 is provided therethrough which enables generally unobstructed movement of fluid, and solid or semi-solid material in the fluid, generally along the axis of the pathway.

In more detail, the conduit 12 comprises a first section 18 of generally uniform cross-section and a second section 20 tapering inwardly away from the section 18 towards an outlet 22. The first section 18 is connectable at its other end 24 to a fluid supply as will be described.

The motion inducing means 14 comprises three rib formations 26 which project, from the inside of the first section 18 of the conduit 12 in equi-spaced relation around the inside of the conduit. The rib

formations 26 extend along the first section 18 following a generally spiral path from the end 24, towards the second section 20, thereby defining three generally spiral channels 28 forming part of the passageway 16.

The rib formations 26 extend inwardly for less the radius of the conduit 10, and thereby define a clear central portion 30 of the passageway 16. This central portion provides a longitudinal unobstructed path for fluid, and solids and semi-solids in the fluid, passing through the conduit 10. The passage of the fluid around the spiral channels 28 induces the swirling motion, as will be explained. This central unobstructed path is particularly important with regards to effluent and sewage treatment, since it enables solids and semi-solids, such as faeces and rags to pass through the device without blocking it, as will also be described in more detail later.

A further important feature of the rib formations 26 is that they are shaped to present no recesses or protrusions which could act to hold solid or semi-solids in the fluid passing through the conduit 10. The rib formations 26 are shaped at their respective surface to blend into the internal surface IS defining the conduit 10 in the direction generally along the longitudinal

axis of the conduit 10 to facilitate entry of fluids and solid/semi-solid constituents thereof into the conduit 10. Fig. 1 shows the surface 29 of one rib formation 26 blending into the internal surface IS. Each rib formation 26 also blends into the internal surface IS in a generally circumferential direction around the inside surface IS, to give each generally spiral channel a part-circular cross-section, as can be seen in Fig. 2. The blended nature of the formation 26 in all directions ensures that the formations 26 provide no places for solid or semi-solids to collect, thus mitigating any problems of clogging and becoming blocked or partially blocked.

Also according to the present invention, and with reference to Fig. 3, there is provided a fluid mixing arrangement 32 comprising a device 10 as described above, and a mixing chamber 34 in communication with the outlet 22 of the device 10. The chamber 34 has an inlet 36 connected to a second fluid supply (not shown) and a discharge opening 38, the outlet 22 of the device being located to send swirling fluid therefrom into the chamber 34 to cause fluid to be drawn from the second fluid supply and mix with the swirling fluid from the device 10 and move towards the discharge opening 38.

In more detail, the device 10 is mounted at one

end of the mixing arrangement 32, with its other inlet end 24 attached to a first fluid supply (not shown). The device 10 extends into the elongate chamber 34, such that the outlet 22 is located generally beneath the region of communication of the chamber 34 with a fluid supply conduit 40 connected to the second fluid supply.

The outlet 22 is located generally part way along a cylindrical section 42 of the chamber 34. The remainder of the section 42 extends away from the device 10 towards a tapered section 44 of the chamber 34 which reduces in cross-section away from the section 42 and connects with a narrow cylindrical section 46, which in turn extends towards a further flaired section 48 of the chamber 34 which it increases in cross-section towards the discharge opening 38.

In operation, the arrangement 32 mixes fluid from the first supply with fluid from the second supply. The fluid from the first supply is pumped into the device 10 through the inlet end 24. The formations 26 induce swirling motion in the fluid, which upon entry into the second section 20 of the device 10 is accelerated as a result of the reduction in cross-section, to be ejected from the outlet 22 in the chamber 34. The speed and movement of the fluid ejected from the device 10 results in reduced pressure in the chamber 34 at the location

beneath the conduit 36, such that fluid from the second fluid supply is drawn into the chamber 34 through the conduit 36, without the need for the fluid from the second supply to be pumped. However, it is to be appreciated that pumping or blowing means may be employed to assist movement of fluid down the conduit 36.

The swirling motion of the ejected fluid also provides efficient mixing of the fluid. The mixture thus formed moves into the tapered section 44 which causes further acceleration of the mixture, through the second cylindrical section 46, and into the flaired section 48. The section 48 causes the still swirling and turbulant mixture to be discharged from the arrangement in a plume of well mixed fluids.

It is to be appreciated that the configuration of the second section 20 and the other sections 42,44,46 and 48 of the arrangement are chosen to ensure that the fluid is discharged at the desired pressure and any pressure/static heads the fluid experiences during and following discharge, are overcome.

It is to be appreciated that the device 10 and fluid mixing arrangement has many applications.

One such application is in the treatment of effluent and in particular sewage, and a further aspect of the present invention is sewage treatment apparatus comprised of a fluid mixing arrangment as described above, and a reservoir 50 for the sewage, the discharge opening 38 of the arrangement 32 being in communication with the inside of the reservoir 50, such that the mixture produced by the arrangement 32 is discharged into the reservoir 50, to facilitate the treatment of sewage as will be described.

With reference to Fig. 4, the fluid mixing arrangement 32 as described above is located within the effluent 58 contained in the reservoir 50. A pump 52 is connected to the inlet end 24 of the device 10 located in the arrangement 32, via a supply conduit 54. A further conduit 56 connects the input of the pump 52 with the effluent 58 in the reservoir 50.

The conduit 40 connects the chamber 34 to air in the atmosphere, which comprises the second fluid supply.

In use, the apparatus 49 is operable to treat effluent and sewage by aerating and mixing the sewage through a recycling process as follows. The pump 52 pumps effluent 58 from the reservoir through the conduit 54 into the device 10 in the arrangement 32. As

explained, the device 10 is operable to induce a swirling motion in the effluent, and then accelerate it out through the outlet 22 into the chamber 34. This relatively high velocity liquid causes a reduction in pressure in the chamber 34, which causes air to be drawn from the atmosphere down through the conduit 40 into the chamber 34. The swirling motion of the effluent enhances the reduction in pressure. The force of pumping generated by the pump 52 can be selected to control the speed of ejection of liquid from the device 10. This provides for control of the rate of discharge from the arrangement 32 and also adjustment to overcome the back pressure exerted by the sewage 58 in the reservoir 50 on the mixture being discharged.

As air is drawn through the conduit 40 into the chamber 44, the swirling motion of the effluent produces efficient mixing of the air with the effluent, and hence aeration of the effluent. This results in superior mixing and aeration of fluid, and in this case the sewage over conventional systems and thereby provides a more efficient treatment of sewage through bacterial action as will be described.

The aerated mixture is then accelerated through the chamber 34 as described, and discharged into the reservoir 50 as a plume shown diagramatically at 60.

The plume 60 mixes with the effluent 58 in the reservoir 50 thereby providing aeration of the effluent 58. This aeration provides the oxygen necessary for bacterial break-down of the effluent 58 by natural processes. The relatively low density of the aerated material causes it to bubble up through the effluent 58 and thereby increases dispersion of the oxygen.

The pump 52 continually recycles effluent 58 from the reservoir 50 through the arrangement 32.

Fig. 5 shows apparatus 149 of a second embodiment of the present invention. The (not shown) device and arrangement 132, are as described above, but the pump 152 is submerged within the effluent 158, and pumps effluent from the reservoir 150 through an inlet 62 into a chamber 132 as described above. The apparatus 149 works in a similar way as to the apparatus 49.

Fig. 6 shows treatment apparatus according to a third embodiment of the present invention. The device 210 and arrangement 232 are generally as described above and features corresponding with aforesaid features are referenced with the same reference number, prefixed with a "2". The device 210 and arrangement 232 are comprised in a conduit system having an inlet conduit I to carry fluid to be treated to the device 210 and an outlet

conduit 0 into which treated fluid is discharged. The outlet conduit may carry fluid to a reservoir, further conduits in the system or any other derived location. The device 210 and arrangement 232 works generally as described above with reference to the alternative embodiments.

This particular embodiment is particularly suitable for aerating or mixing fluids with no or only small solids therein.

Figs. 7 and 8 show an alternative device 310 according to the present invention. The device 310 comprises a conduit 12 having a first, cylindrical portion 64 from which extends a tapering portion 66 reducing in cross-section, towards an outlet 68.

A second conduit 70 connects to the first portion 64 and is inclined relative to the axial direction thereof and is also off centre in relation to the axis of the conduit 312, as can be seen in Fig. 8. The conduit 70 is of smaller cross-section than the first portion 64.

The device 310 is operable to induce a swirling motion as described above in fluid pumped through the second conduit 70 into the first conduit 312. Fluid entering the conduit 312 contacts the inner surface 72 of the conduit 312, which causes the fluid to adopt a

swirling motion towards the outlet 68, as a result of the relative positioning of the conduits 70 and 312. The reduction in cross-section of the tapering portion 66 accelerates the fluid towards the outlet 68. The device 310 is operable in mixing arrangement of the types described above and can operate in a similar manner.

It is to be appreciated that the devices 10, 210, 310 and the arrangements 32,132,232 described above may be operable to mix any two fluids to produce, for example aerated liquids, or liquid-liquid mixtures.

It is also to be appreciated that the devices 10, 210,310 can be used to induce swirling motion in a fluid, whether liquid or gas, for any suitable use.

Various modifications may be made without departing from the spirit or scope of the present invention. For example, the arrangement, angles and number of tapering sections may be varied to provide the desired acceleration of fluids. The precise configuration of the rib formations 26 may be varied, and further or less channels 28 may be provided as required. The rib formations 26 blend into the inside surface of the conduit 12 or taper therethrough, generally at the end 24, to facilitate entry of fluid

into the device 10.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

CLAIMS

1. A device for inducing swirling in fluid, the device comprising a conduit through which fluid is passable, and motion inducing means operable to create swirling motion in fluid passing through the device, the device being arranged such that a passageway is provided therethrough which enables generally unobstructed movement of fluid and solid or semi-solid material in the fluid generally along the axis of the pathway.

2. A device as claimed in claim 1, in which the motion inducing means is so arranged to induce a swirling motion in fluid pumped into the device.

3. A device as claimed in claim 2, in which the fluid is pumped in a direction towards an outlet of the device.

4. A device as claimed in any preceding claim, in which the motion inducing means defines, at least in part, a channel twisting along the perimeter of the passageway, along which some of the fluid is moved and thereby caused to swirl.

5. A device as claimed in claim 4, in which a plurality of channels is provided in the passageway.

6. A device as claimed in claim 5, in which three channels are provided giving the passageway a generally symmetrical Y-shaped cross-section.

7. A device as claimed in any of claims 4 to 6, in which the motion inducing means comprises formations extending from the inside surface(s) of the conduit to define said channel(s).

8. A device as claimed in claim 7, in which the formations partly define a central portion of the passageway generally along the axis of the conduit.

9. A device as claimed in claim 7 or claim 8, in which each formation comprises a rib which follows a twisting path along the passageway.

10. A device as claimed in claim 9, in which the path is generally spiral.

11. A device as claimed in any of claims 7 to 10, in which the formations are shaped to present minimal obstruction to the movement thereover of fluid and any solid or semi-solid components in the fluid.

12. A device as claimed in any of claims 7 to 11, in which the formations are shaped to facilitate entry of

fluid, and solids/semi-solids carried in the fluid, into the passageway.

13. A device as claimed in any of claims 7 to 12, in which the formations taper from an inlet end of the passageway towards the inside of the device to increase to full size inside of the inlet end of the device generally in the direction of the longitudinal axis of the passageway.

14. A device as claimed in claim 13, in which the formations generally blend into the inside of the device to provide lead-in surfaces for fluid into the passageway.

15. A device as claimed in any of claims 7 to 14, in which sides of the formations blend into internal surface(s) defining the passageway.

16. A device as claimed in any of the preceding claims, in which the conduit comprises a first part of uniform cross-section and a second part of tapering cross-section thereby providing acceleration of fluid along the second part.

17. A device as claimed in claim 16, in which the second part reduces in cross-section toward the outlet.

18. A device as claimed in claim 16 or 17, in which the degree of tapering may be varied to increase and/or decrease the pressure of fluid in and leaving the second part.

19. A device as claimed in any of claims 16 to 18, in which the motion inducing means is provided in the first part.

20. A device as claimed in claim 19, in which the motion inducing means extends into the second part.

21. A device as claimed in any preceding claim, in which the motion inducing means comprises a second conduit connected to communicate with the said conduit and inclined relative thereto, such that fluid passing through the said conduit to the second conduit impacts the inside of the second conduit, the impact causing the fluid to swirl.

22. A device as claimed in claim 21, in which the second conduit is located downstream of the said conduit.

23. A device as claimed in any of claims 21 or 22, in which the impact causes the fluid to move towards an outlet in the second conduit.

24. A device as claimed in any of claims 21 to 23, in which the second conduit tapers in cross-section, reducing in cross-section from the direction of the conduit to the outlet, thereby providing for acceleration of the swirling fluid toward the outlet.

25. A device as claimed in any of claims 21 to 24, in which the said conduit communicates with the second conduit in non-central alignment, such that fluid passing from the said conduit to the second conduit is caused to adopt a combined rotational and longitudinal motion along the second conduit, and hence adopt a swirling motion.

26. A fluid mixing arrangment comprising a device according to any of the preceding claims and a mixing chamber in communication with an outlet of the device and also comprising a supply conduit in communication with the chamber and connectable to a second fluid supply, and a discharge opening, the outlet of the device being located to send swirling fluid therefrom into the chamber to cause fluid to be drawn from the second fluid supply and mix with the swirling fluid from the device and to move towards the discharge opening.

27. An arrangement as claimed in claim 26, in which the outlet is located adjacent the connection of the

supply conduit to the chamber.

28. An arrangement as claimed in claim 26 or claim 27, in which the motion created by the device in fluid exiting therefrom is sufficient to reduce the pressure in the chamber at least at or near said connection to cause fluid to be drawn from the second supply.

29. An arrangement as claimed in any of claims 26 to 28, in which the second supply is at or above atmospheric pressure.

30. An arrangement as claimed in any of claims 26 to 29, in which pump means and/or blowing means is/are provided to assist movement of fluid from the second supply toward the chamber.

31. An arrangement as claimed in any of claims 26 to 30, in which the second supply is at atmospheric pressure.

32. An arrangement as claimed in any of claims 26 to 31, in which fluid from the second supply is gaseous and the arrangement provides aeration of a liquid with the gas from the second supply to produce an aerated mixture of liquid to be discharged through the opening.

33. An arrangement as claimed in any of claims 26 to 32, in which the chamber comprises a portion that reduces in cross-section in the direction towards the discharge opening, to provide further acceleration of fluid outputted from the device, toward the discharge opening.

34. An arrangement as claimed in any of claims 26 to 33, in which the reduction in cross-section is predetermined to ensure the desired pressure of fluid moving therealong.

35. An arrangement as claimed in any of claims 26 to 34, in which the chamber comprises a discharge portion increasing in cross-section in the direction towards the opening, to cause the fluid to be discharged from the arrangement in generally a plume.

36. An arrangement as claimed in any of claims 26 to 35, in which the arrangement comprises a part of a fluid treatment conduit system in which the arrangement treats fluid by mixing as aforesaid and discharges the fluid into a further conduit of the system to carry the fluid therefrom away from the opening.

37. An arrangement as claimed in claim 35 or claim 36, in which the discharge portion is located between the

said portion and the discharge opening.

38. Fluid material treatment apparatus comprising a fluid mixing arrangement according to any of claims 26 to 37 and a reservoir for material, the discharge opening of the arrangment being in communication with the reservoir such that fluid mixture produced by the arrangement is discharged into the material in the reservoir.

39. Apparatus as claimed in claim 38, in which means for recycling material being treated is provided.

40. Apparatus as claimed in claim 39, in which the means comprises a conduit system to link the reservoir to the device such that material is recycled from the reservoir, pumped through the device, mixed in the arrangement with fluid from the second supply and discharged back into the reservoir.

41. Apparatus as claimed in any of claims 38 to 40, in which the fluid from the second supply is gaseous, and desirably air, such that the arrangement also provides aeration of the pumped fluid.

42. Apparatus as claimed in any of claims 38 to 41, in which the apparatus comprises effluent treatment

apparatus such as sewage treatment apparatus, operable to pump effluent/sewage through the device to cause the effluent/sewage to swirl and be aerated, and to discharge aerated effluent/sewage into the reservoir, to facilitate degradation of the effluent/sewage, for example, by bacteria.

43. Effluent treatment apparatus comprising a device for inducing swirling motion in effluent passing therethrough.

44. Apparatus as claimed in claim 43, in which the device is according to any of claims 1 to 25.

45. A method of mixing fluid using a device, and/or apparatus according to any of the preceding claims.

46. A method of treating effluent using a device, arrangement and/or apparatus according to any of the preceding claims.

47. A device substantially as hereinbefore described with reference to the accompanying drawings.

48. An arrangement substantially as hereinbefore described with respect to the accompanying drawings.

49. Apparatus substantially as hereinbefore described with reference to the accompanying drawings.

50. A method substantially as hereinbefore described with reference to the accompanying drawings.

51. Any novel subject matter or combination including novel subject matter disclosed, whether or not within the scope of or relating to the same invention as any of the preceding Claims.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report)	Application number GB 9522178.4O
Relevant Technical Fields (i) UK Cl (Ed.O) B1C (CPJA) (ii) Int Cl (Ed.6) B01F 5/00, 5/04, 5/06	Search Examiner J H WARREN Date of completion of Search 31 JANUARY 1996
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii)	Documents considered relevant following a search in respect of Claims :- 1-50

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

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&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2180957 A	(KIYOSHI HORII) see claim 1 and Figure 1	1-4, 6, 16, 17, 26, 28
X	GB 2149679 A	(CONOCO) page 1, lines 89-104	1-3
X	GB 2130908 A	(CONOCO) cyclone 10, 11; page 1, line 125 - page 2, line 42	1, 3, 16, 17
X	GB 1209603 A	(M.S.E.) Figure 2	1-3
X	EP 0627264 A	(VOITH) Ribs 16	1-4, 7, 8
&	US 5437784 A	(VOITH)	1-4, 7, 8
X	US 4834343	(BOYES) see especially Figure 3, tapering formation 17	1-3, 16, 17
X	US 4514343	(AIR-O-LATOR) Figure 3	1-3
X	US 4123800	(MAZZEI) Figure 1	1-3, 16, 17, 21-23

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